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# Evaluation of the Delta-T SPN1 as a sunshine meter.

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# The SPN1





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# Why measure sunshine?

- Measure of climatology of a place, particularly cloudiness.
- Agriculture
- Tourism
- Health
- Solar power
- Can be used as an estimate of global solar radiation



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# WMO specifications for sunshine duration

*The sum of the time for which the direct solar irradiance exceeds **120 W m<sup>-2</sup>**.*

Daily totals of sunshine should be measured with an

- uncertainty of  $\pm 0.1 \text{ h day}^{-1}$  and a
- resolution of **0.1 h**.

0.1 h = 360 s



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# Experimental procedure

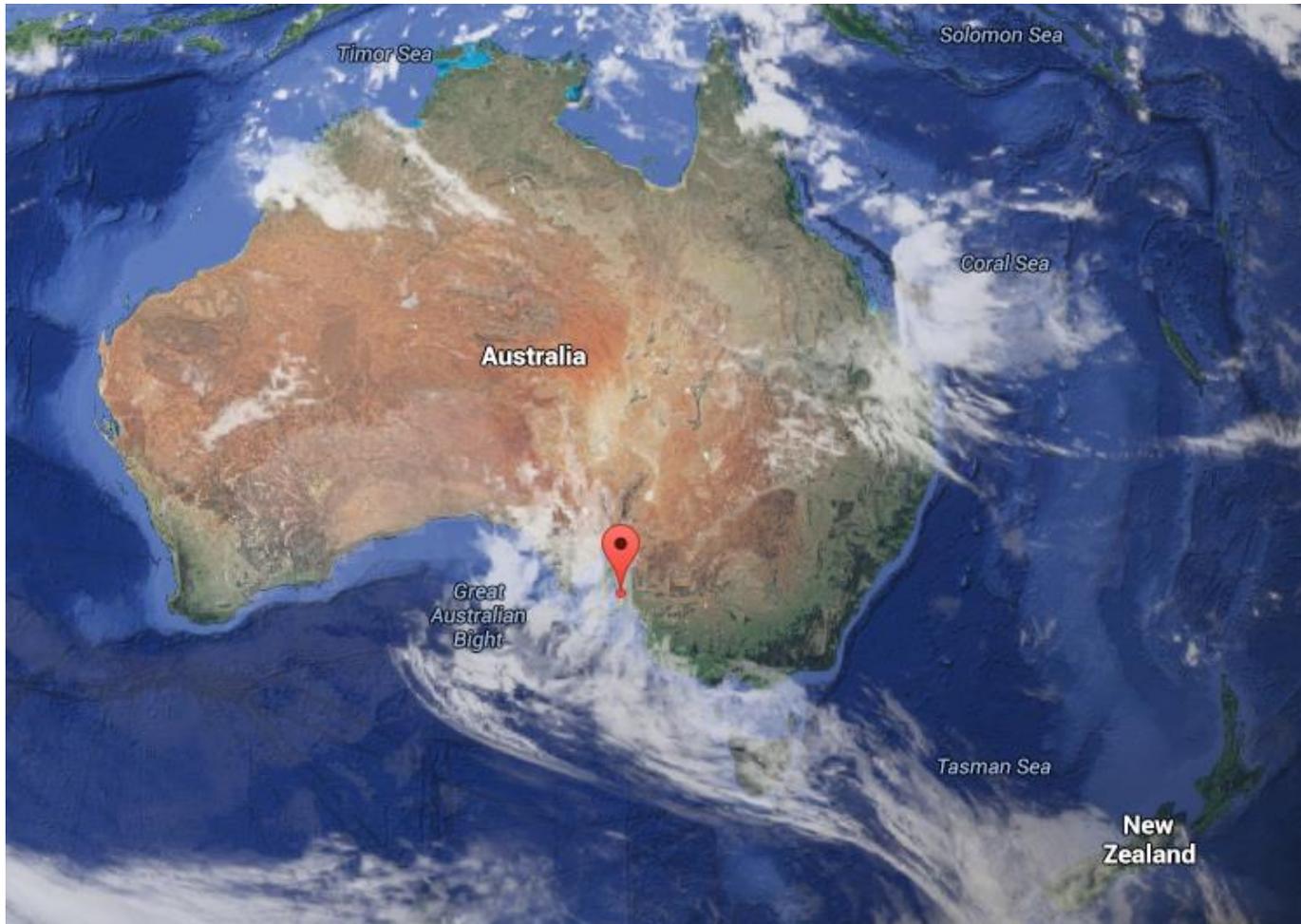
- Compare results from SPN1 to reference (CH1)
- Instruments co-located at Adelaide Airport
- 1s sampling
- Experiment ran for 182 days (2-Oct-2015 to 31-Mar-2016)



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# Location of experiment





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# The SPN1





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# The CH1





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# Calibration of instruments

## SPN1-A124

- Calibrated June 2014
- Factory calibration
- Error after recalibration: 0.1%
- Accuracy =  $\pm 10\%$
- Recalibration recommended every 2 years

## CH1-070592

- Calibrated Nov 2013 & Oct 2015\*
- BoM calibration
- Traceable to WRR
- Uncertainty after calibration  $< 1.5\%$
- Recalibration recommend every year (but we do two-yearly)



# Sunshine statistics for Adelaide Airport

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean daily sunshine (hours)	10.5	10.0	8.6	7.3	5.6	4.7	5.0	6.1	7.2	8.5	9.4	9.4	7.7
Mean number of clear days	12.1	12.1	11.0	7.9	5.0	4.3	4.1	5.2	5.9	6.9	6.8	8.2	89.5
Mean number of cloudy days	7.4	6.5	9.0	12.0	15.3	14.3	15.4	13.5	12.1	11.8	10.8	10.6	138.7



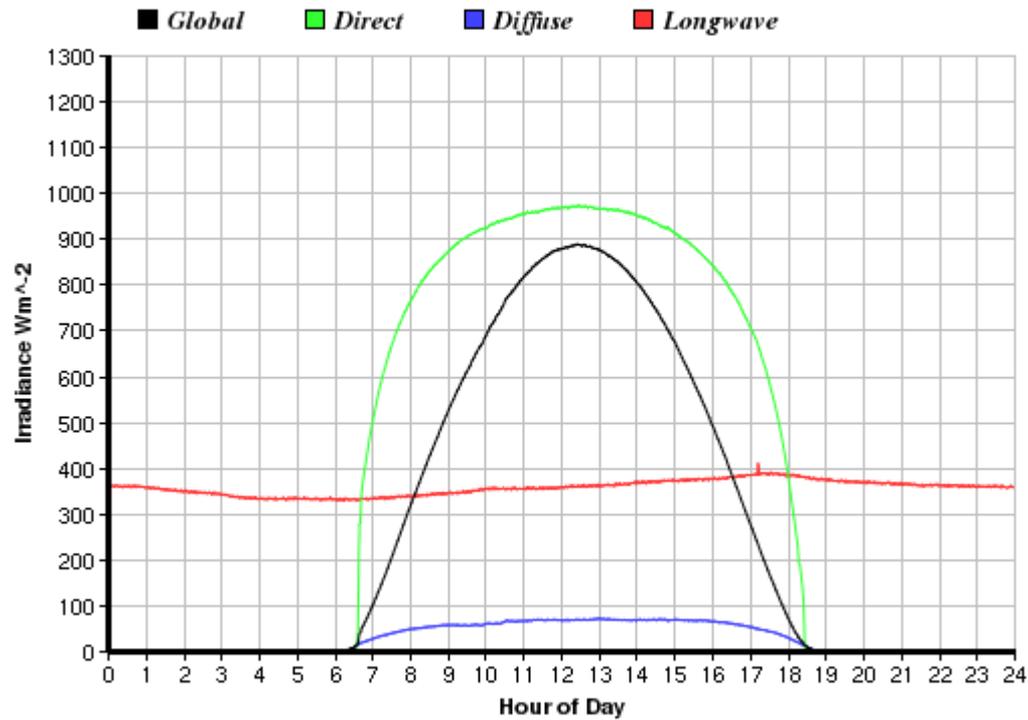
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# A "typical" day

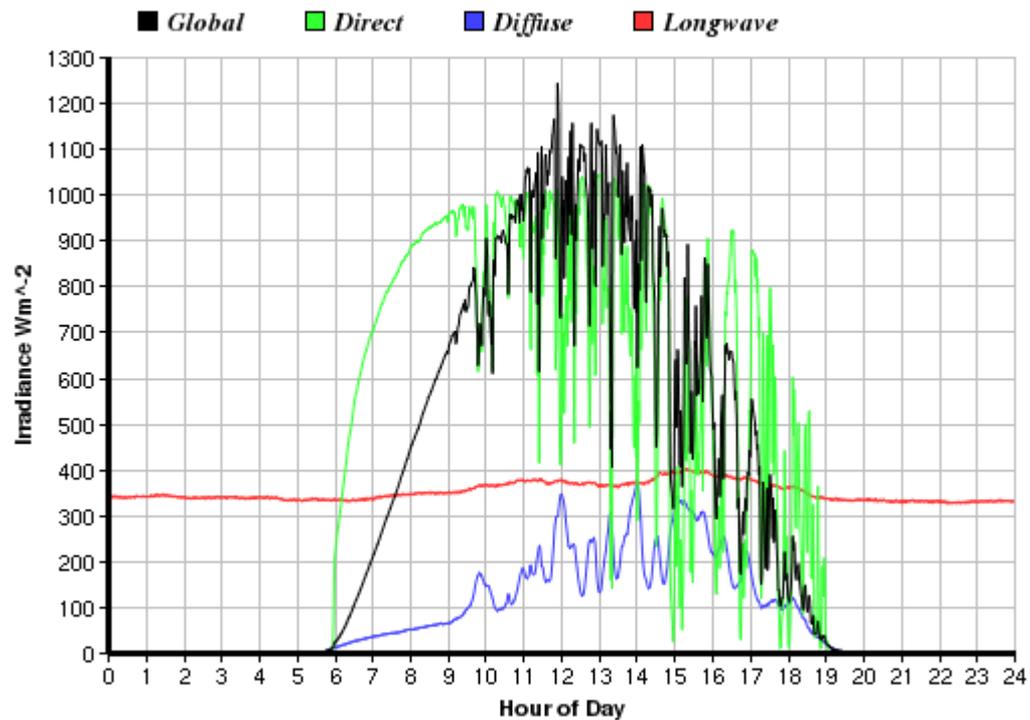
## Mean Irradiances Adelaide 15/3/2016





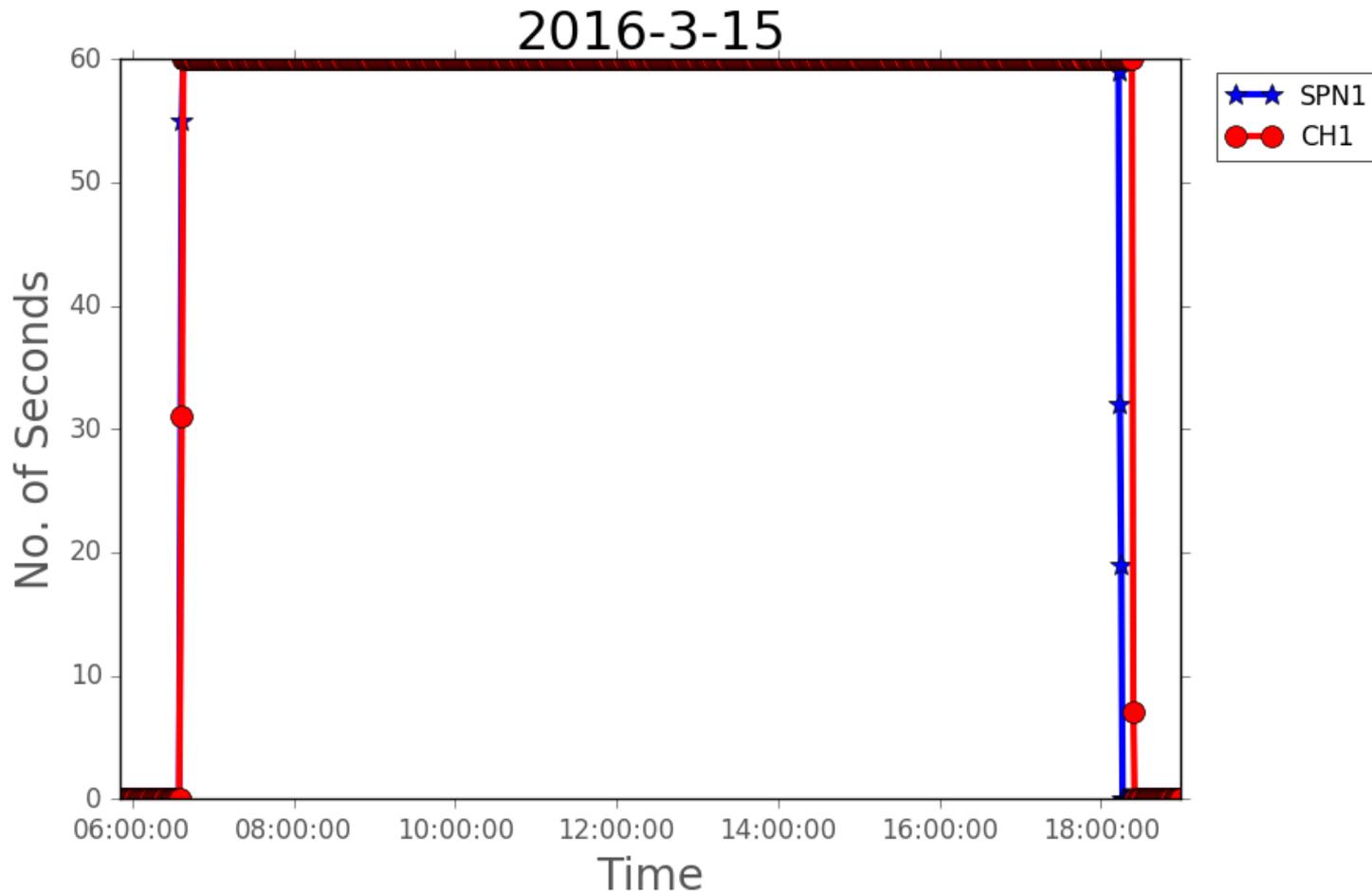
# A much more typical day

*Mean Irradiances Adelaide 10/2/2016*



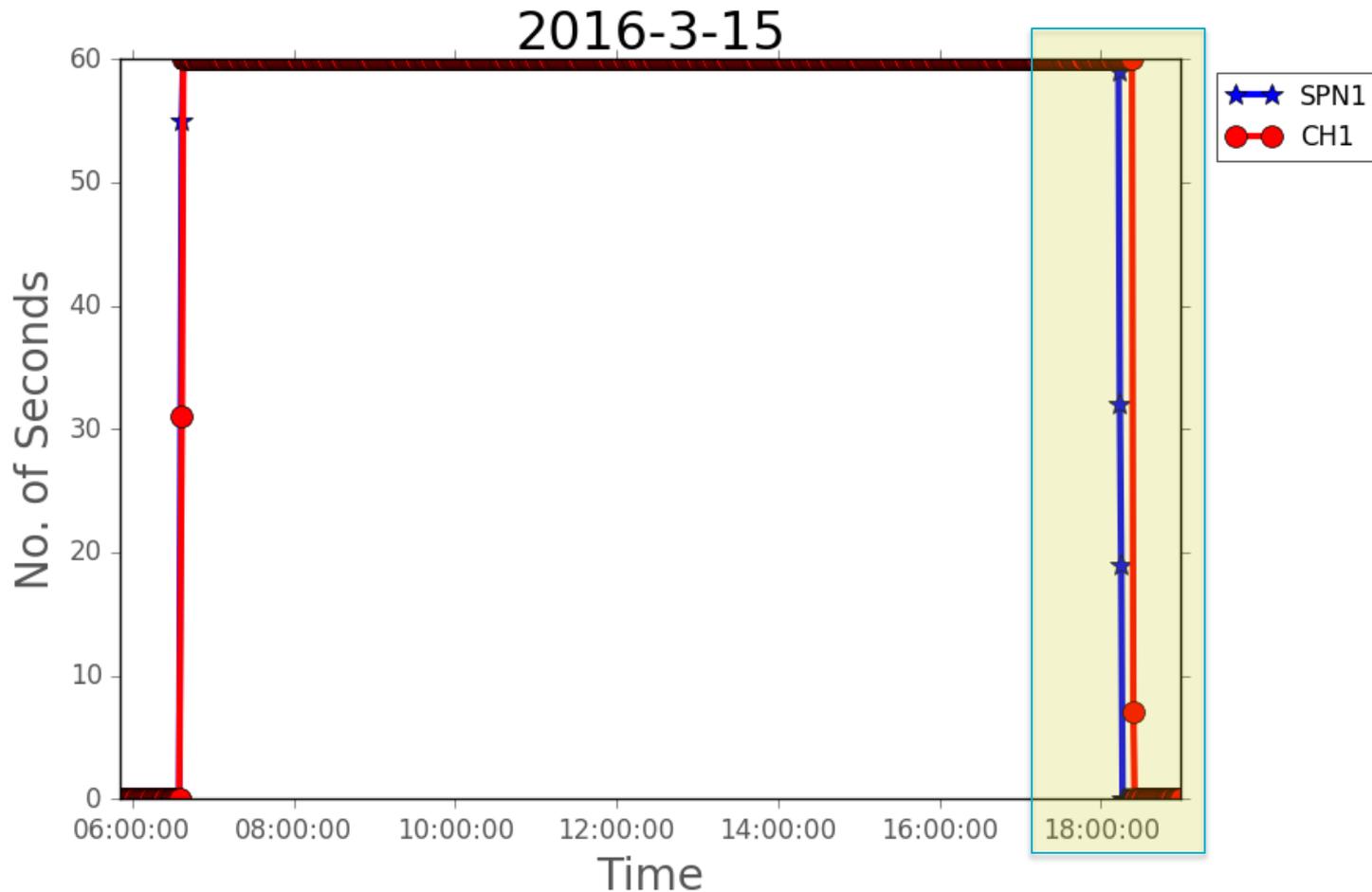


# A typical day from a sunshine point of view





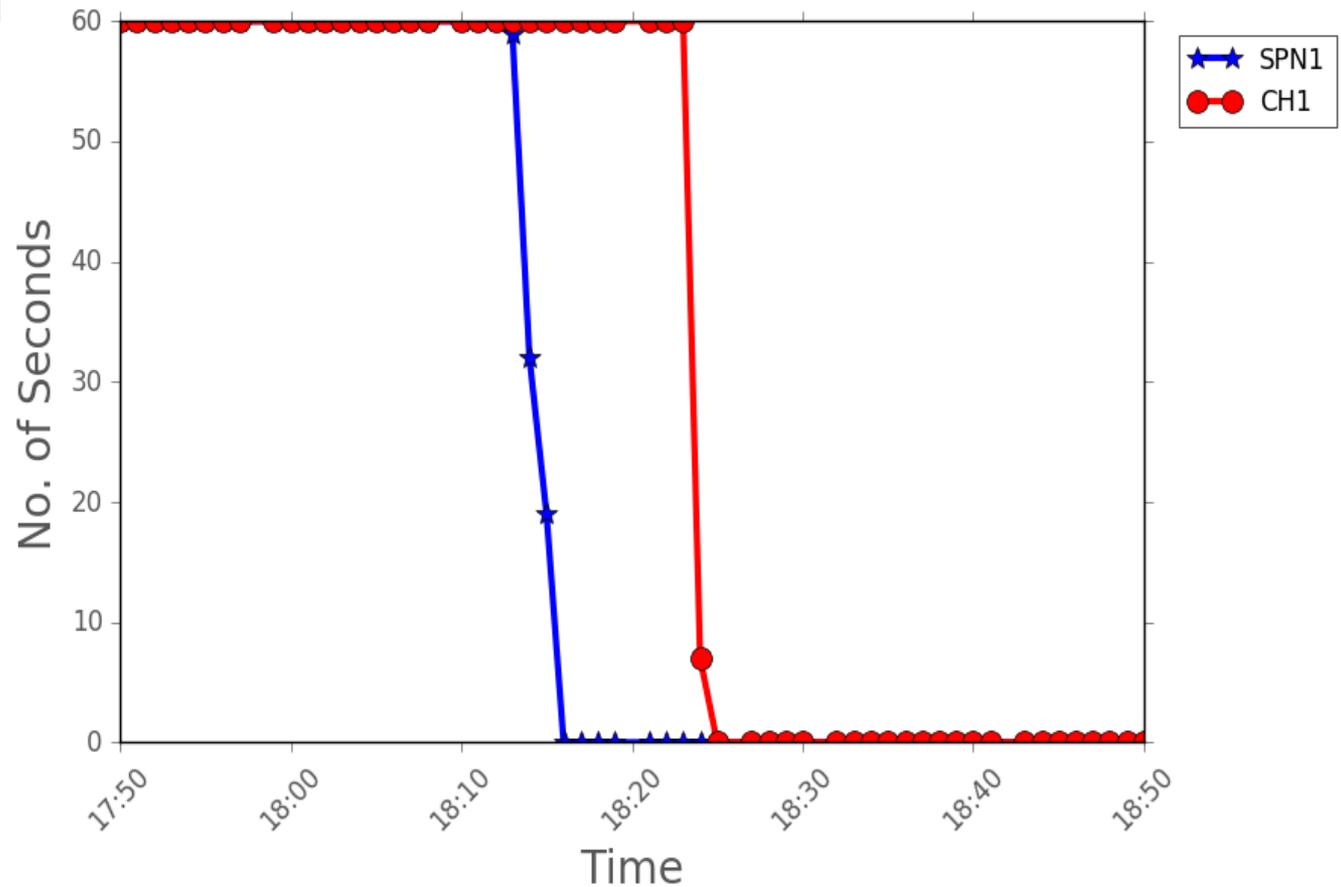
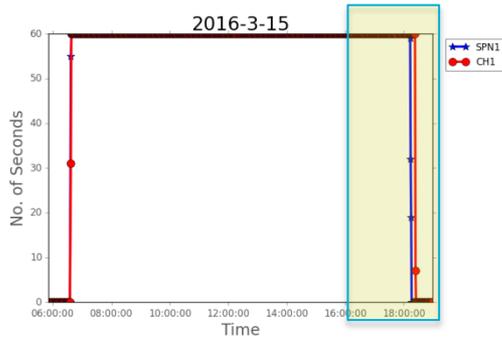
# A typical day from a sunshine point of view





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# A typical day from a sunshine point of view





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## Data selection

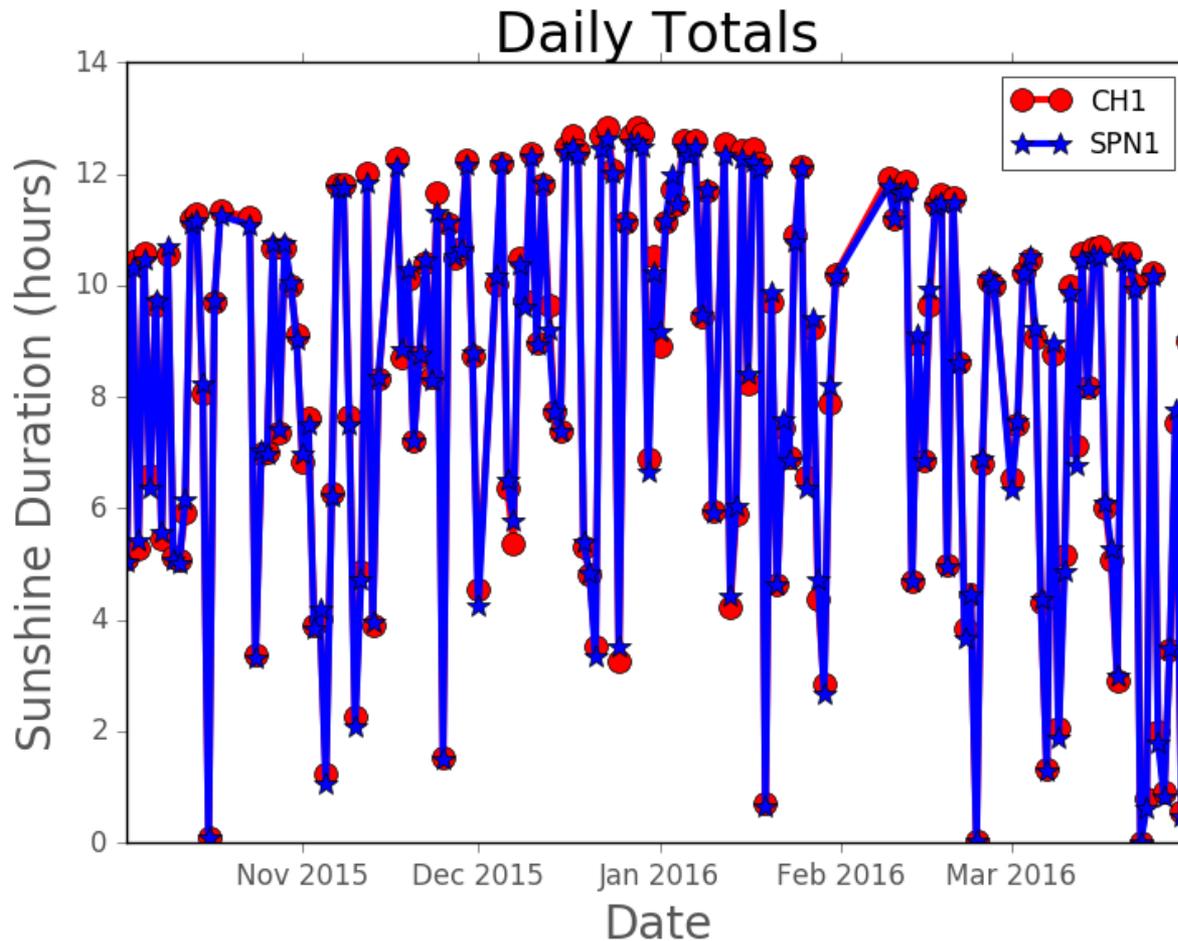
- Data from CH1 undergoes manual QA & removal of "bad" data.
- Each day must have  $> 99\%$  of data from SPN1
- Removed any days that had major tracking issues.
- Removed any minutes that were missing even a single second
- We are left with 163 days and 2121 hours of data



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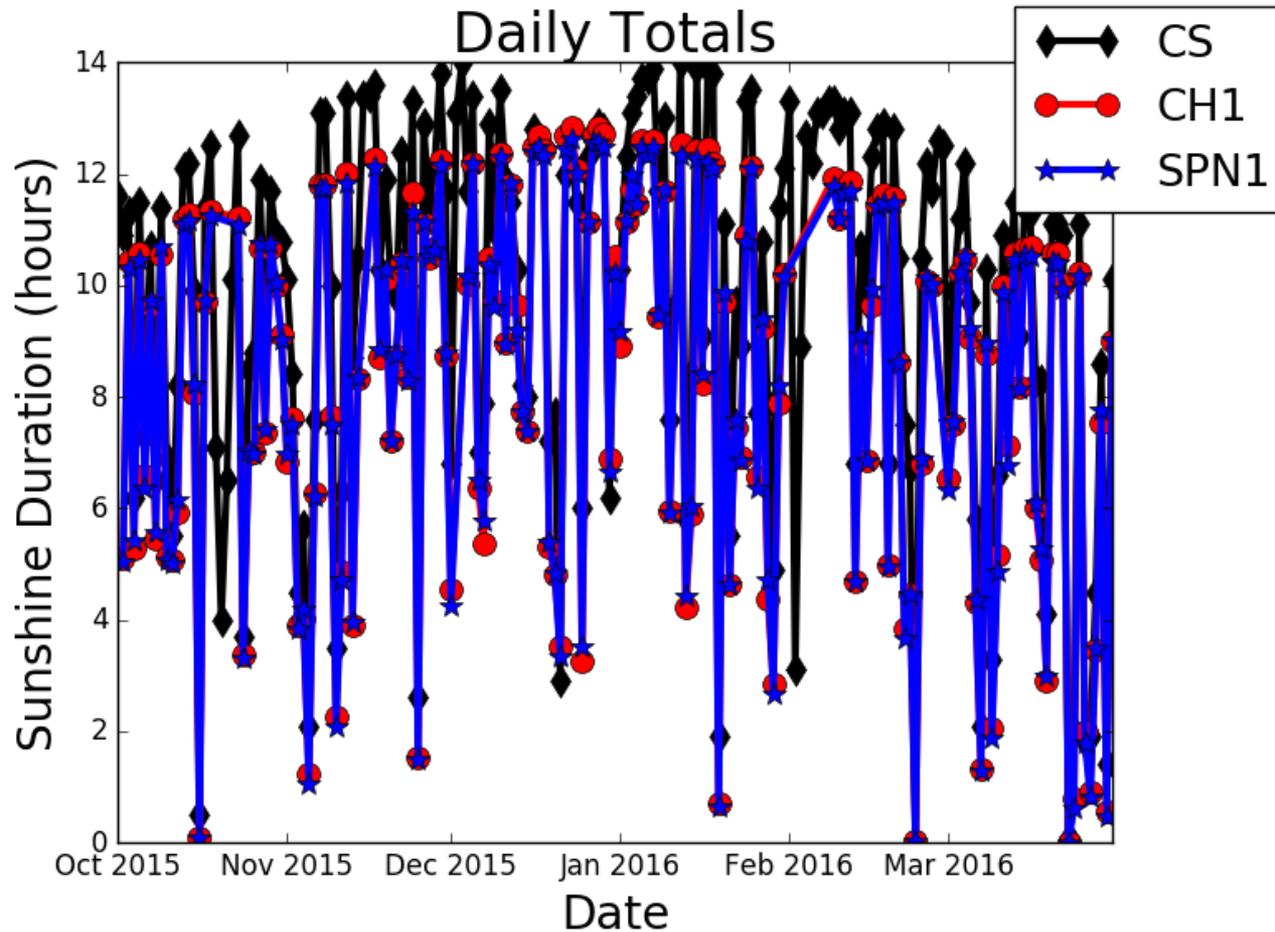
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# Sunshine Duration (Hours) vs Date





# Daily totals including the Campbell Stokes sunshine recorder

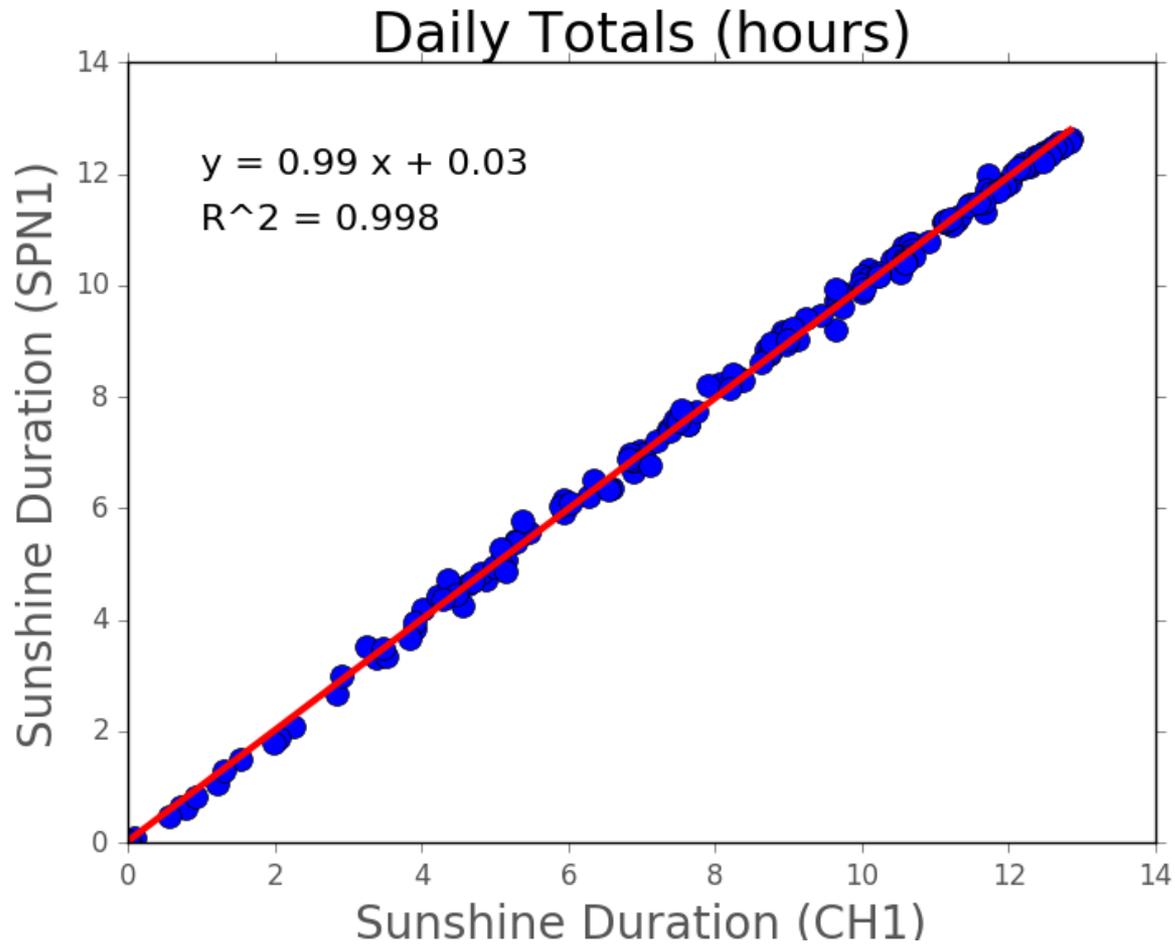




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# Plot of CH1 vs SPN1

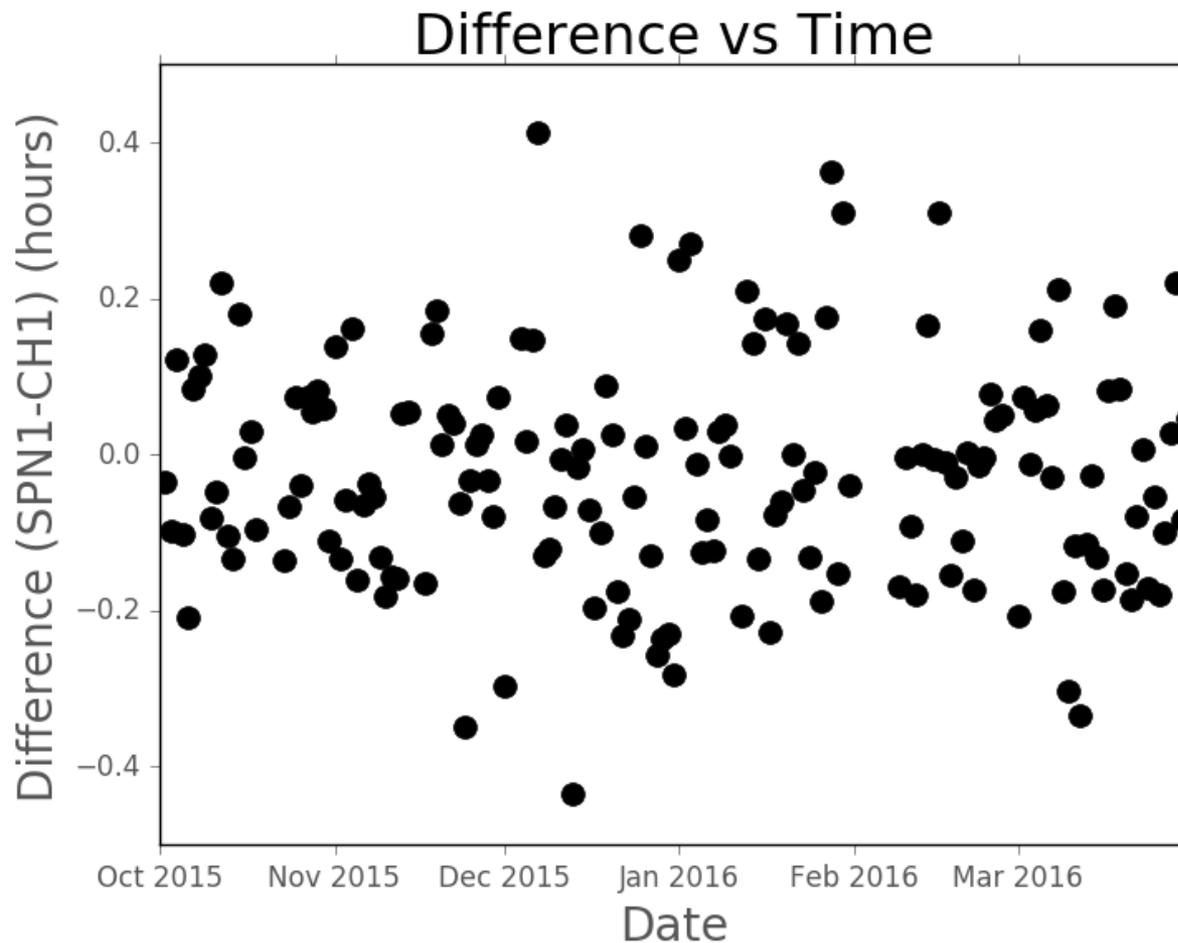




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# Does the difference change with time?

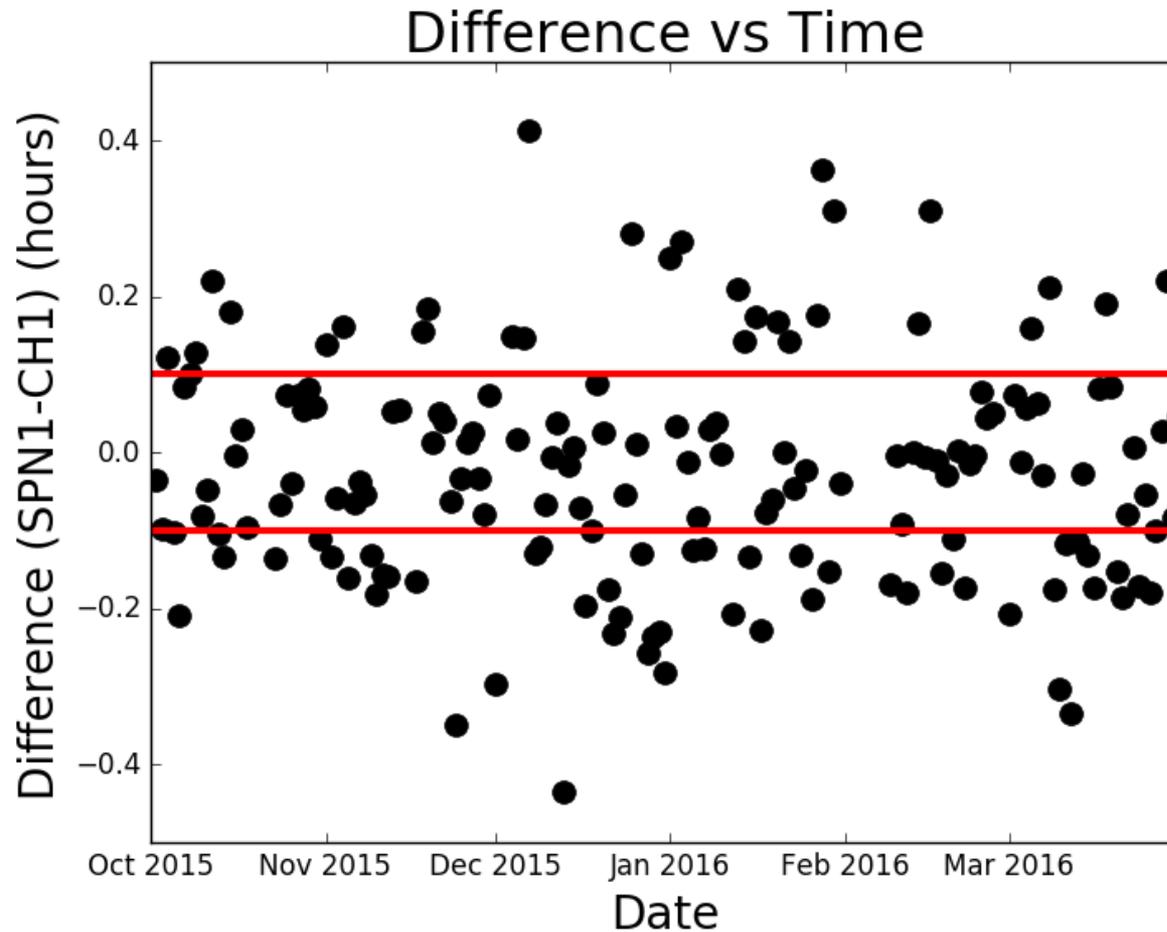




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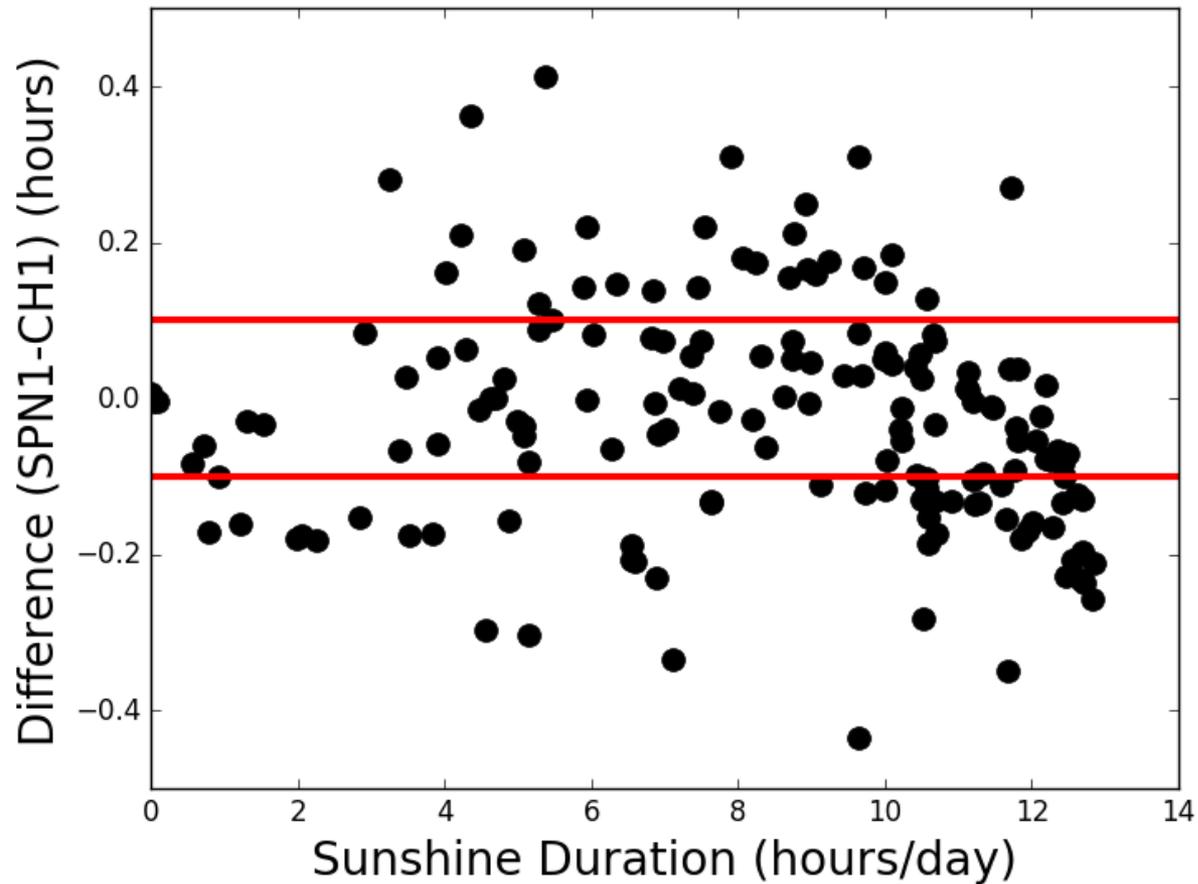




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# Difference vs Sunshine Duration

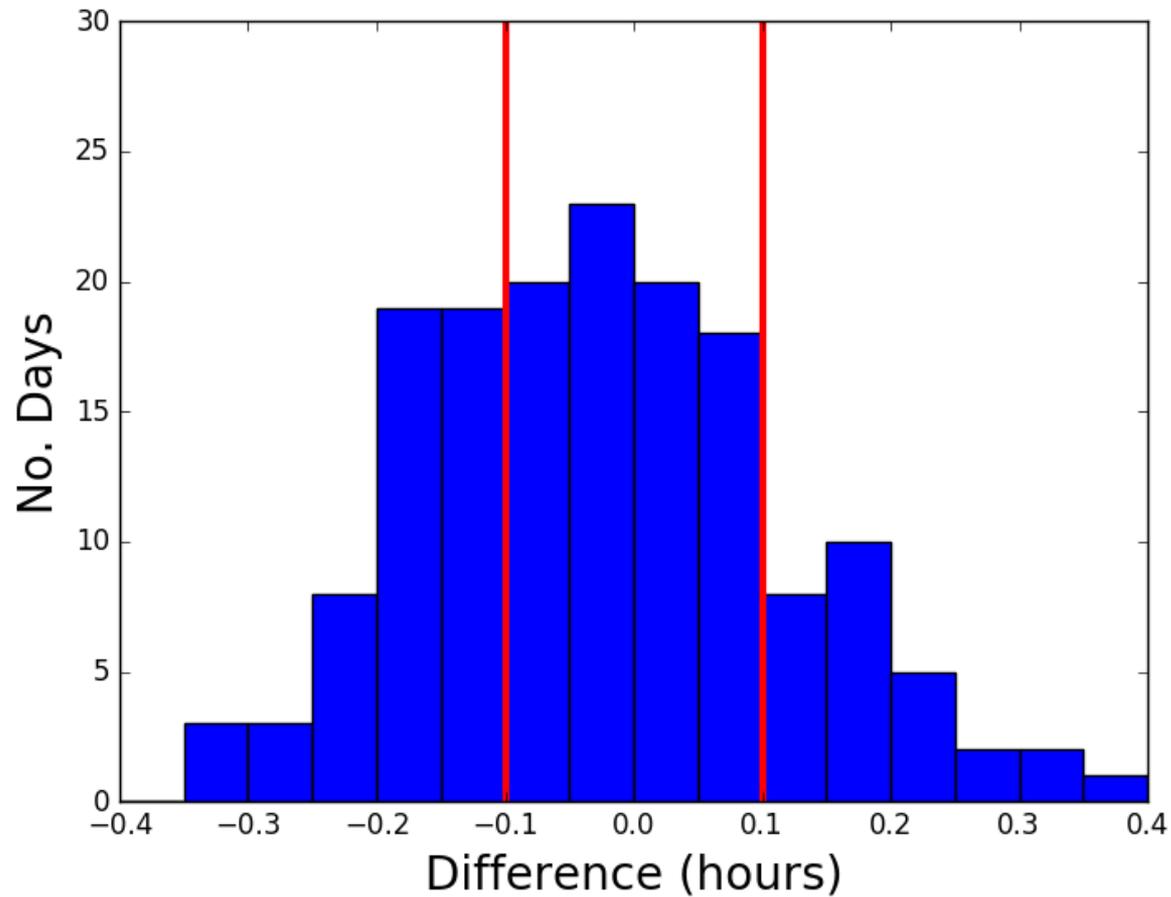




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# Histogram of differences

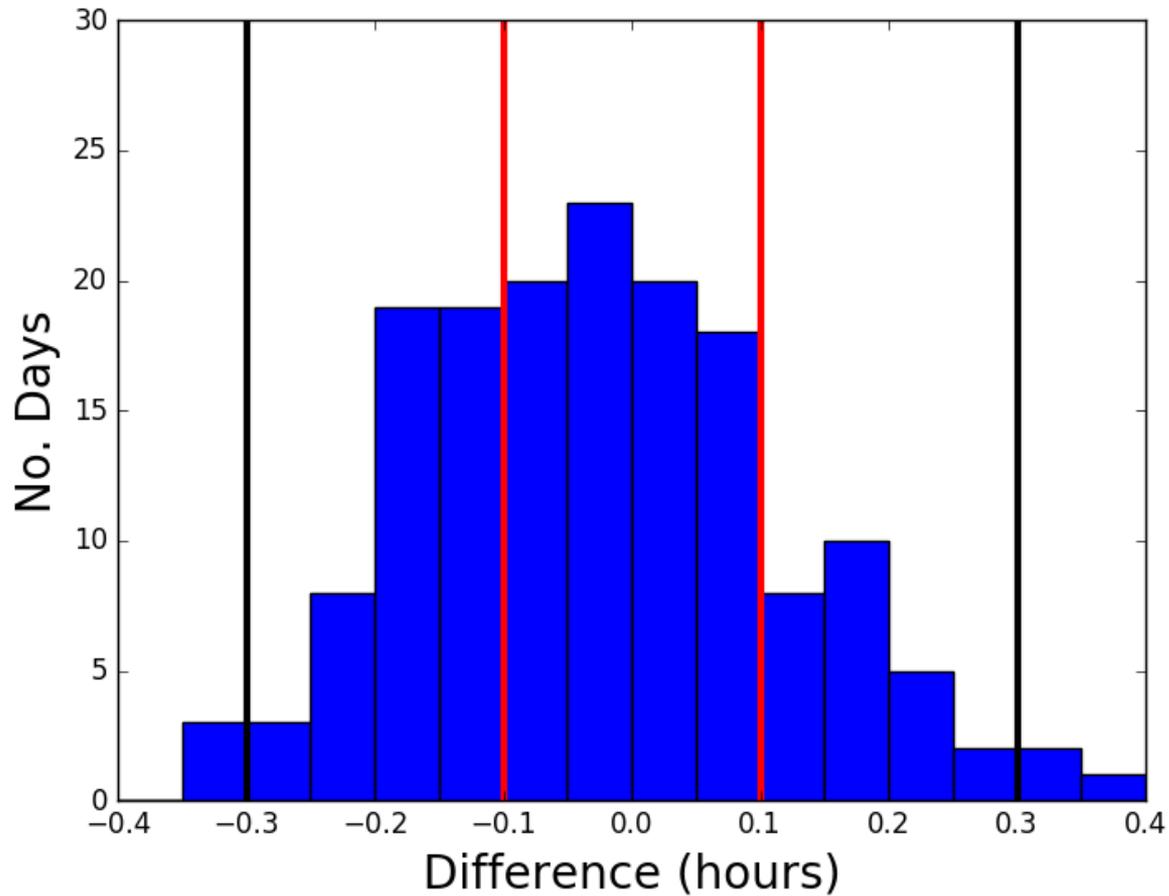




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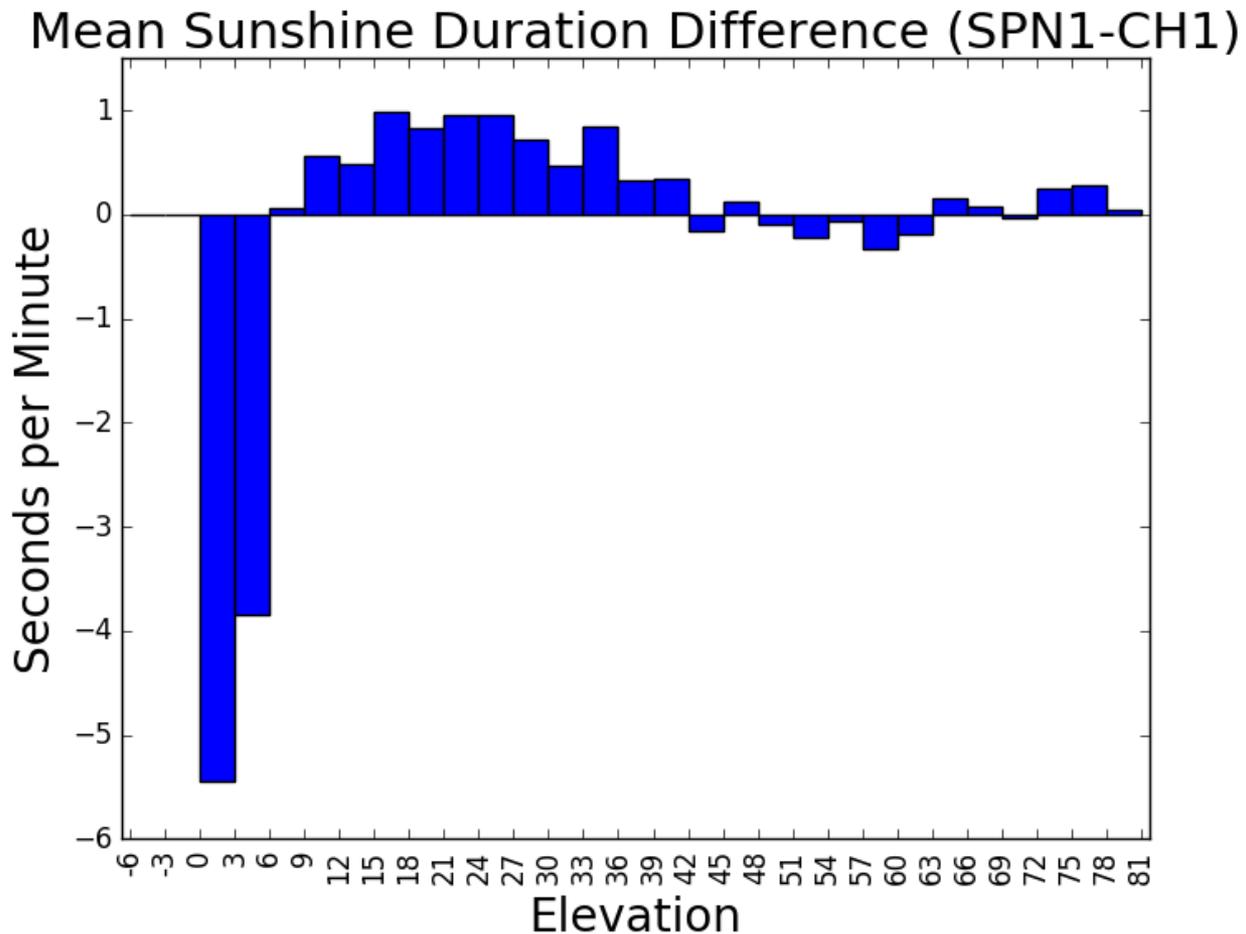
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# Histogram of differences



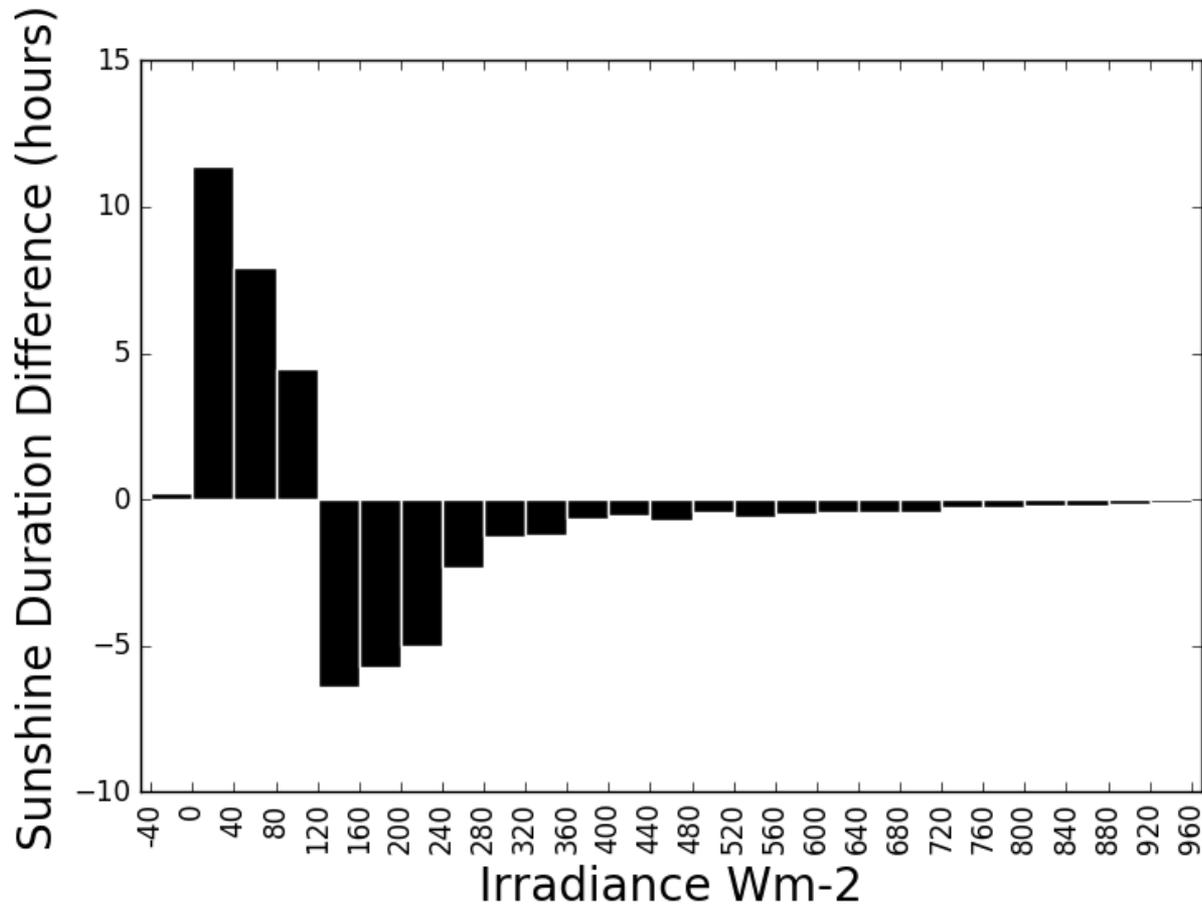


# The contribution of elevation to the uncertainty



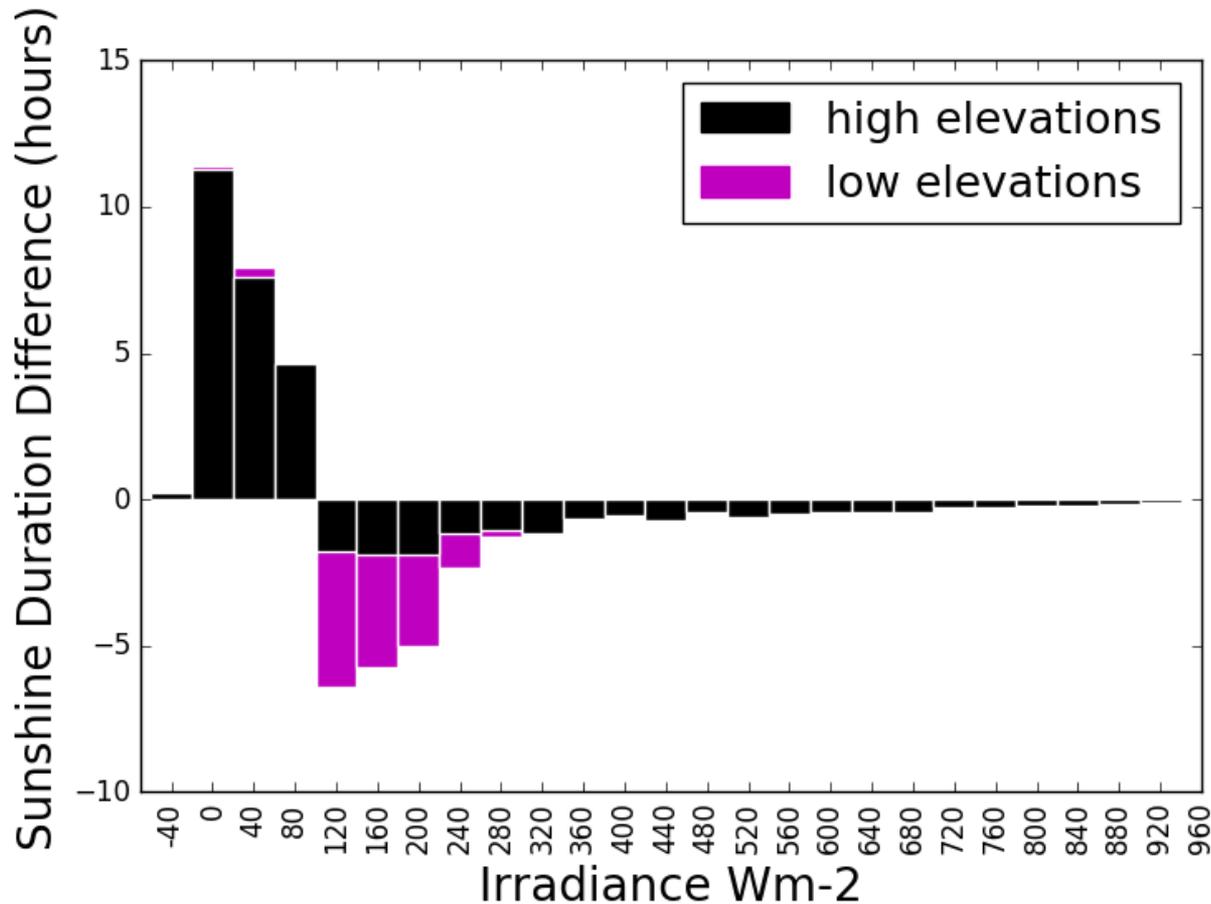


# The contribution of irradiance to the uncertainty



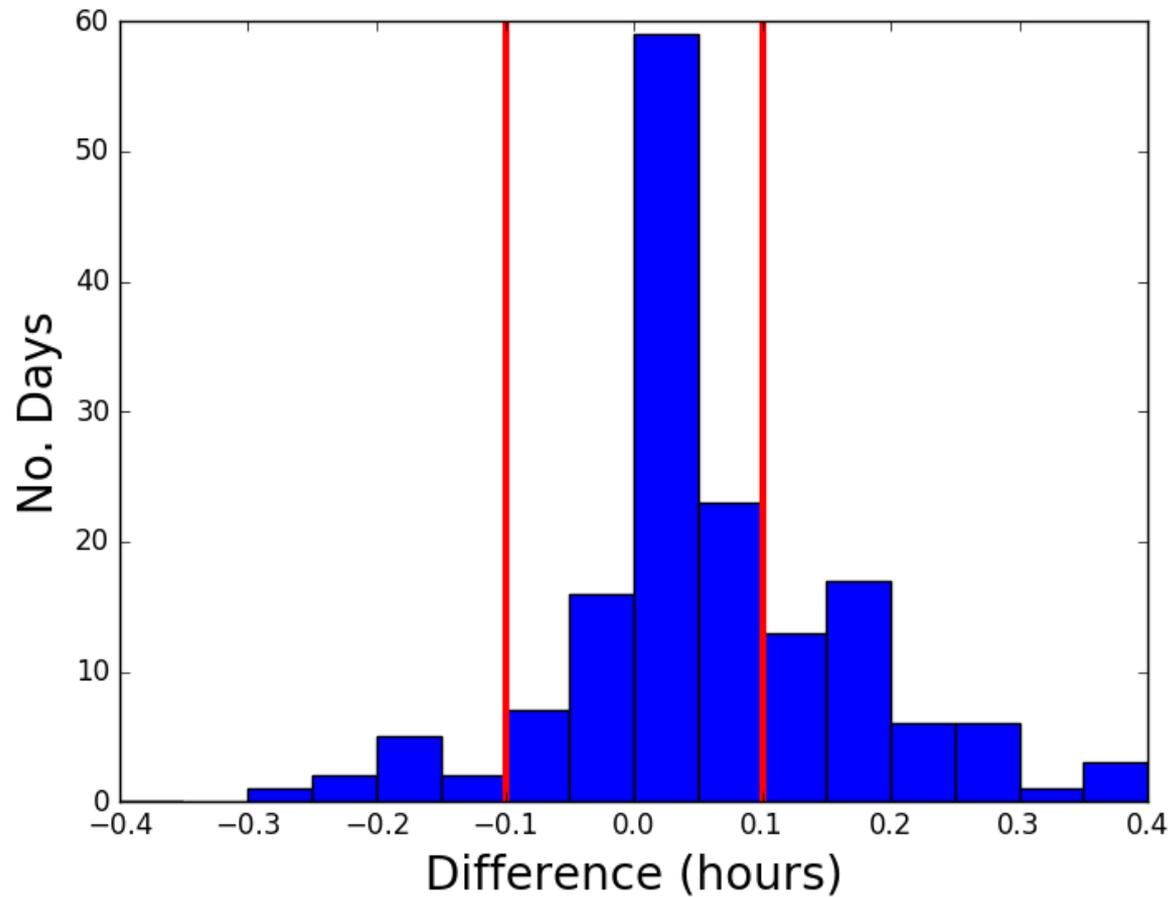


# Difference vs Irradiance (low elevations shown separately)





# Difference with low elevation removed





# Does the SPN1 meet the requirements?

Threshold	Uncertainty	No. of days	% of days
All elevations			
120 Wm <sup>-2</sup>	± 0.1 h	81	50%
120 Wm <sup>-2</sup>	± 0.3 h	155	95%
Elevations > 6			
120 Wm <sup>-2</sup>	± 0.1 h	105	64%
120 Wm <sup>-2</sup>	±0.28 h	155	95%



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# Conclusions

- While the SPN1 does a reasonable job of estimating sunshine duration, it does not meet the WMO standard.
- The SPN1 behaves most poorly at low elevation



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# References

## **User Manual for the Sunshine Pyranometer type SPN1**

Delta –T Devices Ltd

John Wood, 3.0 October 2013

## **Investigation of the accuracy of the Delta-T Devices BF3 Sunshine Sensor**

Instrument Test Report 700

Paul Dyson, July 2005

## **Guide to Meteorological Instruments and Methods of Observation,**

Secretariat of the World Meteorological Organization, Geneva, Switzerland, WMO doc

Eighth edition, 2014

## **Solar irradiances measured using SPN1 radiometers: uncertainties and clues for development**

Atmos. Meas. Tech., 7, 4267–4283,

Jordi Badosa *et. al.*, 2014



# Does the SPN1 meet the requirements? (including other thresholds, all elevations)

Threshold	Uncertainty	No. of days	% of days
96 Wm <sup>-2</sup>	± 0.1 h	59	36%
120 Wm <sup>-2</sup>	± 0.1 h	81	50%
144 Wm <sup>-2</sup>	± 0.1 h	66	40%
96 Wm <sup>-2</sup>	± 0.5 h	155	95%
120 Wm <sup>-2</sup>	± 0.3 h	155	95%
144 Wm <sup>-2</sup>	± 0.4 h	155	95%